Why Image processing?
- improve pictorial informations for human interperetation
- Processing image for
  - Storage
  - Tranmission
  - Representation for autonomous Machine

Image Processing
- input: image
- output: image (improved)

Computer Vision
- input: image
- output: interpretation for image objects

Digital Image:
- Matrix of pixels f(x, y) where f is the intenisty of the pixel

Sources of Images:
- Electromagnitic Waves
- Sound Waves
- Electronic microscope
- Computer Graphic

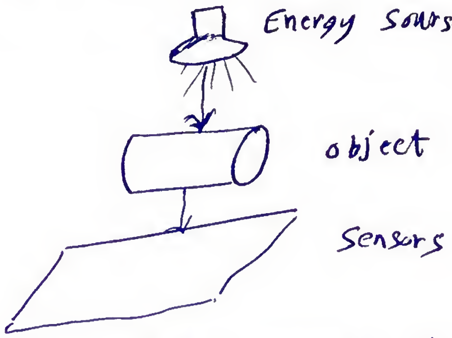
plus

Electromagnitic Waves
- Stream of mass less particles Called photons that move with speed of Light and have a Certain amount of Energy.

* gamma-Rays
* X-Rays
* Ultra Violet
* Visible
* Infra red
* microWaves
* Radio Wave

Image processing and other Areas
- Low Level
  * output is improved image
  Ex: reduce noise, improve contrast
- Mid Level
  * output is extracting features from the image
  Ex: extract Charachtors from image
- High Level
  * output is an interpretation of the image
  Ex: interpreting Charachtors in the image ~~and~~

How Image is generated? (image Sourse)



object can reflet energy or it can pass through the object then Capetured by the Sensor to generate the image

Applications

Gamma ray
- bone Scane
- PET positrone Emition Tomography
- radiations from reactor Valve

X-Ray
- CAT Computerize Axial Tomography To form (3D image)
- Checking Circuit board for missing parts
- Aortic angiogram (image of blood vessels using catheter) أشعة القسطرة

Ultra-Violote
- detect sick Corn

Visible
- Light microscope

Visible / infrared
- remote Sensing
- Weathe Forcasting and observation
- detect bubbles in plastic
- detect un-Fillet bottle in production Line
- circuit board checking for missing parts

Micro Waves

- radar

Radio waves

- MRI Magnitic resonance Imaging

Sound waves

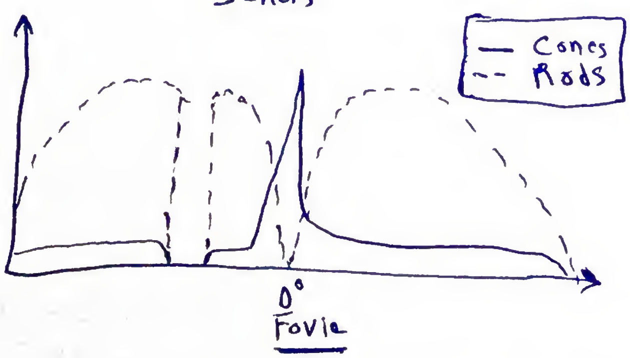
- geological exploration
  * using Flate plate of steel
  * making it vibrate using sound waves
  * sencing the reflecting sound
  * forming image based on distance and speed of sound and strength
- Sonar
  * using probe consisting of source and sensore for ultrasound wave

Slide 23,30 → Check

Lecture.Slides.02

Human-Visual-System-Sensors

- Ratina: Contain two types of sensors
  * Cones: color sensor
  * Rods: Low ~~int~~ Illumination Senors

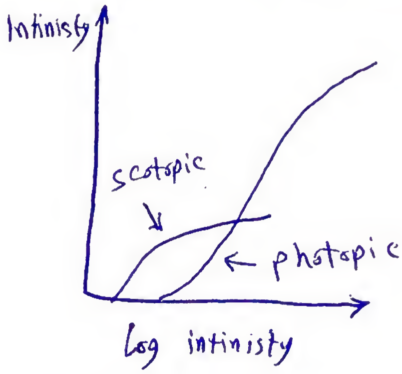


Focal Length

- Vary by chang lens shape
- 14 mm for near object $\leq 3m$
- 17 mm for far object $> 3m$

Brightness Adaptation

- The rang of intenisty that human can sense is varing from the Scotopic threshold and the Glare Limit
- The objective brightness is a Log. function of intinisty
- Scotopic vision: Low intenisty, no-colors
- photopic vision: High intenisty, colered



Brightness discrimination

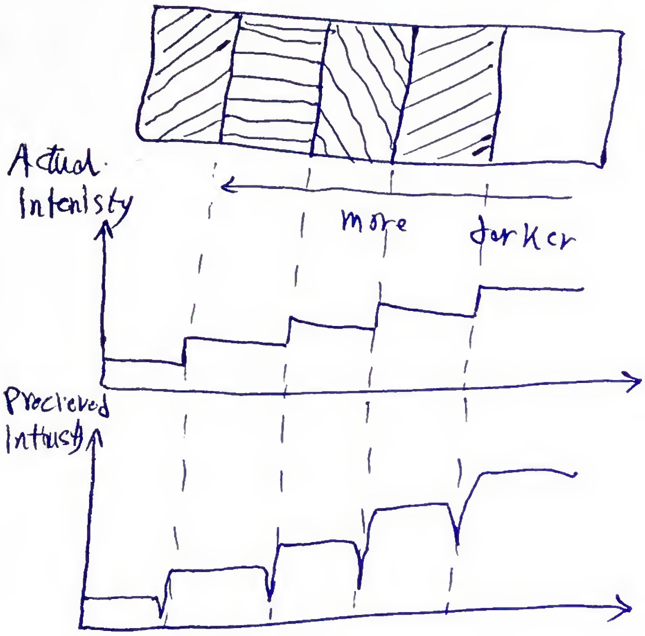
- represent the ability of human to note the change in intinisty
- Varing from person to other
- measured with Weber ratio: the ratio between ΔI_c (the change in the intinisty that can be detected) and I (the intinisty of the background)

$$\boxed{\text{Weber ratio} = \frac{\Delta I_c}{I}}$$

- Good discrimination mean small weber ratio
- bad discrimination mean Large weber ratio

Brightness is not a simple Function of the intinisty :

- The human visual system tends to undershoot or overshoot at the boundry of Mesh bands



- When The background of an object becomes more Lighter the object Looks more darker
- optical illusion

Electro magnitic waves

- Energy $E = h\nu$
  $h \rightarrow$ blank Constant
  $\nu \rightarrow$ frequency
- Wave Length $\lambda = \frac{c}{\nu}$
  $c \rightarrow$ Light Speed $2.998 * 10^8$ m/s

- To see an object the wave Length of EM wave used as energy source must be the same or smaller than the object

Light Charachteristics

- Mono chromatic (achromatic) not colored
  - * intinisty
  - * gray Levels
- Chromatic (colored) Light
  - * Radiance
  - * Luminance
  - * Brightness

Radiance : The amount of energy Flow From Light source (watt)

Luminance: The amount of energy Precieved by observer from Light source (Lumen)(lm)

Type of sensors

1- single sinsor
- resolution depends on the mechanical motion in the booth ~~directions~~ dimmition

2- Strip sensor
- resolution depends on the no. of Sensors in one dimention and the mechanical ~~motion~~ motion in the other

3- Ring sensor
- used to take 3D image Like in CAT

4- Array sensor
- no mechanical motion
- depend on no. of sensors in booth dimintions

Image Model

$0 < f(x,y) < \infty$

$f(x,y) = i(x,y) \cdot r(x,y)$

$0 < r(x,y) < 1$ $0 < i(x,y) < \infty$

Acuoly

$L_{min} < f(x,y) < L_{max}$

$i(x,y)$ illumination

- The amount of energy fall on the surface of Imaged object (lm/m^2)

$r(x,y)$ reflectence

- The ability of object to reflect the fallen energy

Lecture. Slides. 03

Sampling and Quantization

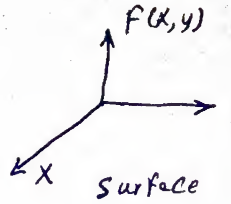
* Sampling: Converting spacial from continuous to discrete
  - Depend on the type of sensor
* quantization: Converting intensty from continsus to discrete
  - Depend on the number of bits used to represent each pixel

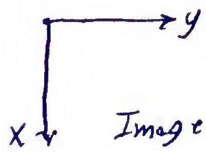
* $(L = 2^k) \rightarrow$ No. of possible gray Levels
* $(M \times N) \rightarrow$ No. of pixels used to represent the image
* $(K) \rightarrow$ No. of bits used to represent pixel
* Dynamic Range $= \dfrac{\text{Max intensty Level}}{\text{Min intensty Level}}$
* Contrast = Max intensty Level − Min intensty Level

* Image size $= M * N * k$ (bit)

Image RerESentation

- Surface
- Image (for human)
- Array ($M \times N$) ~~for algorithms~~ for Algorithms





Notes:

- Max intensty Level is controld by saturation
- Min intensty Level is Controled by the noise

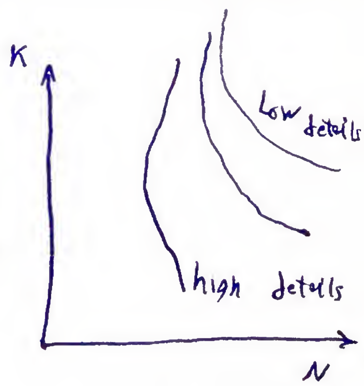
Resolution

~~Spatial~~

* Spacial resolution
  - No. of pixels per unit distance
  - Affected by the distance between the pixels
  - Unit to measure it is DPI → Dot Per Inch
* Intinsty Level resolution
  - No. of possible intinsty Levels (L)
  - No. of bits used to represnt the intensty of each pixel (K)

Iso refrence Curves

- each ~~line~~ curve represent equal quality images
- $K \rightarrow$ No. of bits (intensty)
- $N \rightarrow$ No. of pixels (spacial)
- When details increase we need Low intensty resolution
- When details decrease we need High intensty resolution
- The curve tents to be vertical in image with high details because we
  - need Low intensty Levels to represent the image in good quality



Interpolation

* The operation of filling holes in the image
* holes: pixels with unknown intensty Level after ~~perpho~~ performing some operations on the image
  Ex: Stretching the image

Types of Interpolation

* Nearest Neighbor
  - Low quality
* Bilinear
  - Good quality
  - use 4 nearest neighbor
  - use this equation
    $F(x,y) = ax + by + cxy + d$
* Bicubic
  - High quality
  - use 16 nearest neighbor

Neighbors of Pixels

$N_4(P) \rightarrow$ Set of horizontal and Vertical neighbors

$N_D(P) \rightarrow$ Set of Diagonal neighbors

$N_8(P) \rightarrow N_4(P) \cup N_D(P)$

	X	
X	P	X
	X	

$N_4(P)$

X		X
	P	
X		X

$N_D(P)$

X	X	X
X	P	X
X	X	X

$N_8(P)$

Adjecent: The set of neighbors that are part the Adjecency set V

$V = \{1\}$

$$\begin{matrix} 0 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \end{matrix} \qquad \begin{matrix} 0 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix} \qquad \begin{matrix} 0 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

4-adjacency 8-adjacency m-adjecency

* 4-adjacency:

The pixels p and q are 4-adjecent when q belongs to V and q belongs to $N_4(P)$

* 8-adjacency:

The pixels p and q are 8-adjecency when q belongs to ~~V~~ V and q belongs to $N_8(P)$

* m-adjacency: (mixed)

The pixels p and q are m-adjecent when q belongs to V and
1- q belongs to $N_4(P)$, or
2- q belongs to $N_D(P)$ and the intersection of $N_4(P)$ and $N_4(q)$ is not part of V

$N_4(q) \cap N_4(P) \notin V$

Distance measure

~~Manhattan~~

* Euclidean distance
  - The distance of straight line between the two pixels

$$d_e = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

$$\begin{matrix} \sqrt{8} & \sqrt{5} & 2 & \sqrt{5} & \sqrt{8} \\ \sqrt{5} & \sqrt{2} & 1 & \sqrt{2} & \sqrt{5} \\ 2 & 1 & 0 & 1 & 2 \\ \sqrt{5} & \sqrt{2} & 1 & \sqrt{2} & \sqrt{5} \\ \sqrt{8} & \sqrt{5} & 2 & \sqrt{5} & \sqrt{8} \end{matrix}$$

* Manhatten Distance (city block)
  - The distance between N_4 is 1
  - The distance between N_8 is 2
  - Form diamond ~~Rem~~ shape
  - $d_m = |x_1 - x_2| + |y_1 - y_2|$

		2		
	2	1	2	
2	1	0	1	2
	2	1	2	
		2		

* Chessboard distance
  - The distance between N8 is 1
  - Form Squar shape

2	2	2	2	2
2	1	1	1	2
2	1	0	1	2
2	1	1	1	2
2	2	2	2	2

- $d_c = \max(|x_1 - x_2|, |y_1 - y_2|)$

Lecture.slides.04

Array operations

- Each pixel operats with its Corresponding pixel
- Default

Matrix operations

- Standard matrix operations
- If Stated

Linear operations

- operations are Linear if they are homogenity and additavity

→ $H[a f(x,y)] = a H[f(x,y)]$ homogenity

→ $H[a_1 f_1(x,y) + a_2 f_2(x,y)] = a_1 H[f_1(x,y)] + a_2 H[f_2(x,y)]$
additavity

~~Addition~~

- Sum of all pixels is Linear
- min is not Linear
- max is not Linear

Application on Arthimatic

Addition

* Reduce noise using the Avarage of many noisy images taken by the Same Sensor for the Same Sense

Subtraction

* Mask mode Radiography
  1. We take an X-ray image for region of patient's body. $F(x,y)$
  2. We take an other image after injecting contrast medium in patient's blood stream. $h(x,y)$
  3. We can See the flow of medium using subtraction. $h(x,y) - F(x,y)$
* See difference between two images

Multiplication

* Shading Correction
  - We take an image using the Same Sensor for Constant intensty object. $h(x,y)$
  - We can correct shading by dividing the target image by $h(x,y)$
* Masking
  - We multiply a binary Image with our target image to Obtain the region of ~~[illegible]~~ interest.

Correcting Range of the result

- After performing an operation the resulting intensty Values can be negative or more than the max-value.

- Create the min is zero

$$F_m(x,y) = F(x,y) - \text{Min}[F(x,y)]$$

- Scaling Image intensty

$$F_s(x,y) = L\left(\frac{F_m(x,y)}{\text{Max}[F_m(x,y)]}\right)$$

where L is No. of gray Levels

Sets Operations → slides 12 : 17

Lecture. Slides. 05